Cell Phone Antennas, Problems and Solutions

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Abstract. A novel monopole internal antenna for mobile handsets is presented. The antenna, called the MB antenna, is a modified monopole whose radiating element is implemented in parallel proximity of a ground plane hence allowing for use as an internal antenna in handset applications. Simulation studies indicate that the proposed MB antenna has superior performance over PIFA antennas commonly used in modern handsets. Advantages include compact size, high gain and high efficiency. These characteristics make it very promising to use the proposed MB antenna in mobile handsets, including enhanced SAR reduction capabilities. The principle, design procedure, simulation results and comparison with PIFA also presented.

Keywords: monopole, PIFA, Cell phone, SAR, MB

1. Introduction
Among other properties, the cellular phone handsets’ antennae are required to be of small size, and installed in parallel to and nearby a PCB (printed circuit board) which acts as a ground plane. Mobile communication devices started with wire antennae such as monopole and modified monopoles [1, 2, 3]. The main advantages of these antennas are omnidirectional pattern in the horizontal plane, easy design procedure and light weight. However, in case of cellular handsets, especially at lower frequency bands, these antennas are relatively long and hence they have been realized as external antennae. Since monopole antennae must be installed vertically to a ground plane, they cannot be realized as internal antennae in cellular handsets [4]. Therefore, as the size of the cellular handsets has shrunk, the monopoles have been replaced by inverted L antennas (ILAs), inverted F antennas (IFAs), and at last by planar inverted F antennas (PIFAs) [5]. PIFAs are characterized by broad bandwidths and pure resistive input impedance. Theses antennae are currently widely used in compact cellular handsets. However, the performance of the PIFA is very sensitive to variations in its dimensions and the feeding point, making it difficult to achieve an optimal design of this antenna.

In this paper we introduce a novel monopole antenna, called the MB antenna, whose radiating element is in parallel to a ground plane. The proposed antenna can be easily implemented in handsets which require internal antennae and are subject to space limitations such as the mobile phone handsets. Simulation studies show that the MB antenna performs similar to the conventional monopoles offering all advantages of the latter for use in cellular handsets.

2. The MB antenna
Conventional monopole antennae implemented in parallel to a ground plane exhibit a very poor efficiency. This is attributed to the fact that the fields associated with currents in the ground and the radiating element cancels each other, as shown in Fig. 1. The proposed MB antenna is a modified monopole implemented in parallel to a ground plane. The main idea behind the proposed MB antenna is to introduce a non radiating phase shifting line of 180 degrees so that the current in the ground plane and the current in the radiating element are in–phase and in the same direction, thereby resulting in a constructive superposition of the fields produced by these currents. The antenna consists of a ground plane, a straight line (either a printed strip or a wire) conductor acting as the radiating element and a phase shifting line used for phase shifting. This allows the proposed monopole to be implemented in parallel to the PCB inside cellular handsets.

Figure 1: Monopole is parallel to PCB
Fig. 2 shows two different implementation schemes of the time delay line. All these components can be integrated in a single module consisting of a PCB, a phase shifting line, and a radiating element. As shown in Fig. 2, the signal is fed into the antenna as an unbalanced feed, the ground of the feeding line is connected to the antenna’s ground plane, and the signal is connected to the radiating element via the phase shifting line. The main properties of the proposed antenna such as the radiation characteristics are similar to those of conventional monopoles and hence the proposed antenna is highly suitable for cellular handset applications.

The proposed MB antenna can be designed for multi-band applications. In this case, radiating elements of different lengths should be used, where the lengths of each radiating element and its phase shifting line correspond to the central frequency of one of the required bands. Fig. 3 shows a double band MB antenna.

5. Comparative simulation of PIFA and MB antenna

The proposed MB antenna simulation was studied by the CST software package. Fig. 4 shows the simulation results for the S11 parameter for an operating frequency of $f \approx 1.8$ GHz, showing a bandwidth of about 30%. Fig. 5 shows the simulation results for the far field characteristics of the MB antenna. As it can be seen in this figure the MB antenna exhibits very low level of radiation in the vertical direction, and hence the gain is increased.

Table 1 shows the main characteristics of the MB antenna in comparison to those of a PIFA.

![Figure 2- Two types of phase shifting line](image2)

![Figure 3. Multi band MB antenna.](image3)

![Figure 4- Simulation results for S11](image4)
Figure 5- simulation results for the far field characteristics of the MB antenna

Table 1. PIFA and MB antenna simulations results.

<table>
<thead>
<tr>
<th>Antenna type</th>
<th>Freq. [GHz]</th>
<th>SL1 [dB]</th>
<th>Rad. efficiency [dBi]</th>
<th>Total efficiency [dBi]</th>
<th>Directivity</th>
<th>Far field</th>
<th>( V_{th} ) at excitation port for E = 30( \mu )V/m at distance 5m. [mV]</th>
<th>Gain [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB antenna</td>
<td>1.305</td>
<td>-24</td>
<td>-0.002</td>
<td>-0.0139</td>
<td>4.382</td>
<td>16.565</td>
<td>4.384</td>
<td></td>
</tr>
<tr>
<td>PIFA</td>
<td>0.9</td>
<td>-15.9</td>
<td>-0.224</td>
<td>-2.094</td>
<td>2.148</td>
<td>27.3</td>
<td>1.92</td>
<td></td>
</tr>
</tbody>
</table>

In conclusion, we have presented a novel monopole antenna that can be realized as an interior antenna in cellular handsets. The gain of the proposed MB antenna is larger by 2.9dB compared to PIFA. The MB antenna can be implemented inside compact cell phone handset and allows for multiband operation. Our simulation results show that the proposed MB antenna has superior performance over PIFA in terms of compactness (height=0), gain, radiation pattern. Its performances are not degraded by the PCB inside the handset. MB antenna can be a good basis for developing cellular antennae of low SAR [6 – 9].

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